

Becquerel's comparative experiments (see "Electricity," first edition, vol. ii, p. 235).

This led me to revise the calculations given in the "Phil. Trans.," 1877, and I see that in the final formula in that paper $2R$ has been used instead of R . This makes the value of the constant there given double its true value, which is—

$$\omega = 1.52381 \times 10^{-5}.$$

This correction removes the discrepancy between my result and Becquerel's.

V. "Note on the Irregularities in Magnetic Inclination on the West Coast of Scotland." By T. E. THORPE, F.R.S., and A. W. RÜCKER, M.A. Received October 20, 1883.

In the Report of the results of the Magnetic Survey of Scotland, undertaken at the request of the British Association by the late Mr. Welsh during the years 1857 and 1858, it is stated by Professor Balfour Stewart (by whom the observations were reduced and the report drawn up) that the values of all the elements as determined in and adjacent to the Island of Mull were apparently largely affected by local attraction, and from a comparison of the various observations Professor Stewart was led to place the centre of the disturbance a little to the south of the Mull stations, and at a considerable depth below the surface. The effect of this local attraction was most apparent in the determination of the dip, which at Tobermory was upwards of $57'$, and at Glenmorven, on the other side of the Sound, was $14'$ in excess of the probable normal value, that is, the value unaffected by local disturbance and dependent merely on geographical position, as deduced by combining together all the other observations for Scotland, in the manner adopted by Sir Edward Sabine in discussing the observations of the previous Survey of 1836.

Dr. Stewart's localisation of the centre of disturbance was based partly on a consideration of the abnormal values exhibited by the observations made at the two stations on the Sound of Mull, and partly on certain irregularities manifested by the determinations taken on Islay and in Skye. So far as the Mull observations themselves were concerned, the clue as to the exact locality of the area of disturbance was of the very slenderest. Mr. Welsh appears to have made only a single observation of the dip at Tobermory; and although observations were made with two needles at Glenmorven, the divergence between the resultant values happens to be greater than is exhibited by any other pair of dip observations throughout the survey. Nevertheless, as we shall show, we are able to confirm

not only the general accuracy of Mr. Welsh's observations on this particular point, but also Professor Stewart's inference as to the probable *locale* of the area of disturbance.

Since the date of the publication of Professor Stewart's Report, the Island of Mull, and the adjacent district of Morvern, have been made the subject of very careful geological and petrological study, more particularly by Professor Judd (see his paper in the "Quart. Journ. Geol. Soc.," xxx, 220), who has demonstrated that the great central mountain group in the island is the denuded core of an immense volcanic pile, the base of which must have had a circumference of at least forty miles, and the lava streams from which must have flowed to enormous distances and in quantities so vast as to have accumulated to a thickness of 2,000 feet. We have in these huge accumulations of gabbro, dolerite, basalt, tachylite, &c.—all rocks containing more or less magnetite and, possibly, even finely-divided metallic iron, as in the basalts of the north of Ireland and of Greenland, an undoubted source of local attraction, sufficient in all probability to affect the needle to the extent observed by Mr. Welsh.

It seemed to us highly desirable, however, to repeat Mr. Welsh's observations in the light afforded by Mr. Judd's analysis of the geological features of the district. Although the geological facts doubtless serve to strengthen the validity of the magnetic observations, it should be stated that the direct evidence as to the existence of the great area of local attraction practically rested upon a single set of observations. It appeared to us, therefore, desirable, as a preliminary step to any subsequent survey of the west coast of Scotland, to confirm, in the first place, Mr. Welsh's observations as to the existence of the local attraction; secondly, to ascertain, if possible, the position of maximum disturbance; and thirdly, to determine the influence of the area on the direction of the isoclinal line.

Our observations were made with an excellent dip-circle belonging to Owens College, for the loan of which we are indebted to Professor Balfour Stewart. The instrument is known as "Dover No. 6"; it had already been employed by one of us in magnetic observations in America and in the Azores (see "A Magnetic Survey of the Fortieth Parallel in North America," "Proc. Roy. Soc.," vol. 30, 132; and "Note on the Magnetic Inclination in the Azores," "Proc. Roy. Soc.," vol. 31, 237). The circle is provided with two needles, each $3\frac{1}{2}$ inches long and 0.27 inch in maximum width. Similar precautions were taken to preserve the needles from rust as are indicated in the communications referred to, and the method of observation was the same as that previously adopted; it is identical with that described by Mr. Welsh in the "Admiralty Manual of Scientific Inquiry," third edition, 1859. With a single exception duplicate and independent observations were made in all cases with the two needles.

Our plan of investigation was briefly as follows :—In the first place we sought for a station sufficiently remote from the supposed area of disturbance, and itself free from any suspicion of local attraction, where we could hope to obtain a perfectly normal value for the inclination. We then proceeded to confirm this value by observations made at distances of a few miles and in different directions from this station on spots as free as possible from local attraction. Our normal station we found on the Island of Shuna in Loch Linnhe; this island is composed of alternations of micaceous schist and limestone, and a careful examination of the locality by our colleague Professor Green, to whom we are indebted for the geological notes which accompany our observations, revealed nothing which could exercise any disturbing influence on the dip. The subsidiary stations were near Carron Point in Loch Aber and on the shore of Loch Corrie. We then approached Mull along lines converging to the supposed place of maximum disturbance, making observations at tolerably regular intervals as we came towards the volcanic district as indicated on Professor Judd's map of Mull and Morvern. In this manner we imagined we should be able to determine the influence of the attractive mass upon the dipping needle. We next made observations near but not actually upon the extreme edge of the basalt in Morvern and on the opposite shore of the Sound; and lastly we made a number of determinations on Mull itself with a view of ascertaining, if possible, the position of the maximum disturbance.

The results are contained in the following table (see next page):—

These results serve, in the first place, to establish most unequivocally the existence of the area of local attraction which Dr. Stewart found to be indicated by the observations of Mr. Welsh. In the table showing the results of Mr. Welsh's observations, contained in the Report to the British Association, no particulars are given as to the exact spot in Tobermory on which the tripod was placed, nor is anything to be obtained on this point from Mr. Welsh's MS. notes of his survey work which are kept at the Kew Observatory. Nevertheless, when regard is had to the secular change in the inclination, our results are as concordant as could be expected. Nothing is, of course, known as to the precise amount of this change at Tobermory, but assuming that it is identical with that calculated by Dr. Stewart from the whole of the results of the surveys of 1836-7 and 1857-8, viz., an average yearly decrease of $2'23$, our value would become $72^{\circ} 43'$, which agrees closely with that observed by Mr. Welsh, viz., $72^{\circ} 46'8$. This agreement would in all probability be actually closer if we assume that we have in Scotland as in England a progressive augmentation in the amount of secular change with an increasing westerly position.

Our observations further tend to show that the centre or focus of

Station.	Latitude.	Longitude.	Date 1883.	Greenwich mean time.	Needle.	Dip.	Mean dip.	Geological character of station.
Island of Shuna, Loch Linnhe	56 34 56 N.	5 23 18.7 W.	Sept. 8	h. m. 2 57 P.M.	1	70 56	70 54.5	{ Alternations of micaceous schist and limestone. Sand and gravel resting on quartz felsite. Hills around schist with syenite. Granite: some basaltic dykes.
Near Carron Point, Loch Aber	56 43 30	5 15 45	" 9	3 55 "	2	70 53	71 08.5	
Loch Corrie, Upper end	56 37 07	5 31 07	" 11	12 12 P.M. 10 26 A.M. 11 16 "	2 1 2	71 08 71 12 71 10.5	71 11.2	
Kinloch Aline, Loch Aline	56 33 54	5 45 00	" 12	11 31 " 12 8 P.M.	1 2	71 12 71 6	71 09	
Fishish Bay, Sound of Mull	56 30 22	5 50 00	" 12	4 5 " 4 45 "	1 2	70 27 70 27	70 27	{ Mica schist and gneiss. Just on the edge of the great spread of basalt which covers the north part of Mull and Morvern. Observations made on felsite but near the north margin of the great central intrusive mass of gabbro and basalt. Basalt.
Bietich Island, Sound of Mull	56 37 04	6 02 45	" 14	7 56 A.M.	1	70 58	70 58	
Tobermory, Mull	56 36 59	6 03 50	" 13	11 39 " 12 23 P.M.	1 2	71 46 71 44	71 45	{ Well in the middle of the great basaltic spread. Mica schist and quartzite traversed by basaltic dykes: about half mile from the north boundary of spread of basalt. Mica schist and quartzite: a basalt dyke about 50 yards from place of observa- tion. Basalt: to the west of the great central mass of gabbro. Basalt.
Loch Drumbuy, Morvern	56 38 54	5 56 05	" 13	4 11 " 4 57 "	1 2	71 21 71 27	71 24	
Gobbar Island, Loch Ailort	56 50 55	5 46 55	" 14	4 21 " 4 54 "	1 2	71 16 71 22	71 19	
Soribay Bay, Loch Tuadh	56 29 04	6 10 20	" 18	9 5 A.M. 9 52 "	1 2	72 15.3 72 14.1	72 14.7	
Aird Kilfinichen, Loch Scridain	56 22 39	6 03 45	" 19	10 1 " 10 36 "	1 2	70 41.4 70 39	70 40.2	

Mr. Whipple, the Superintendent of the Kew Observatory, has been good enough to furnish us with a statement regarding the Kew magnetographs which includes the period from September 8th to the 19th, from which it appears that there were no movements of the magnets which could affect our observations on any of the above days.

the area of attractive matter in Mull is near the upper part of Loch Tuadh or Loch Na Keal; that is to say, at about the spot indicated by Dr. Balfour Stewart as its probable place. This spot is certainly very close to, and may indeed on a more complete examination turn out to be identical with the locality where Professor Judd places the great volcanic vent in the island.

The observations, moreover, show that great as may be the absolute mass of the magnetic matter in Mull, its influence extends to no very great distance from the island. The observations in Loch Aline to the north-east, and in Loch Scridain to the south-west, prove that the masses of igneous rocks, as these are constituted in Mull, may be approached to within a very few miles without appreciable effect on the needle. The determination of the normal direction of the isoclinal line in the neighbourhood of Mull is not likely therefore to be materially affected by this area of attractive matter. It is almost certain for instance, that the area was without sensible influence on the observations at Shuna, Carron Point, Loch Corrie, and Loch Ailort. At Loch Drumbu the influence of the Morvern basalt is appreciable, whilst at Fishnish the effect of the horizontal component of the attractive force is very marked. Although this place is only about five miles in about the normal direction of the isoclinal from Kinloch Aline, there is a difference of $42'$ in the dip, an amount of course far in excess of any possible error of observation.

Our observations lastly afford some indication of the probable amount of the secular change in the inclination in these parts. So far back as 1836·5, Sir Edward Sabine found the dip at Artornish to be $72^{\circ} 43'$; this place is close to Kinloch Aline where we this year found the dip $71^{\circ} 9'$; this is equal to an average yearly decrease of $2'$. At our station in Shuna we observed the dip $70^{\circ} 54' \cdot 5$; the interpolated value for 1858 as obtained from the chart accompanying Professor Stewart's report is $71^{\circ} 45'$; this too is exactly equal to a yearly decrease of $2'$. It is worthy of note that this value is identical with that adopted by Sir Edward Sabine in the reduction of all the Scotch observations made prior to 1858 to the mean epoch of 1842·5 ("Contributions to Terrestrial Magnetism," No. XII, "Phil. Trans.," 1870, p. 265).

Our observations are, of course, too few in number, and are distributed over too restricted an area to allow us to draw any definite conclusions as to the direction of the isoclinals at the present time, but it is almost certain that this direction will now be found to be very different from that observed by Mr. Welsh in 1858. It is to be hoped that before very long another magnetic survey of the whole of the British Isles will be set on foot. So far as Scotland is concerned the present time would appear to be very opportune for a new survey.

More than twenty-five years have elapsed since Mr. Welsh made his survey, and this was separated by an interval of twenty-one years from that which we owe to the joint labours of Sir Edward Sabine, Sir James Ross, and Mr. Fox. The instruments and methods of observation in 1858 were greatly superior to those of 1836-7, and hence a new survey made during the approaching period of minimum sun-spot disturbance, and on stations selected with careful reference to their geological character, would undoubtedly afford far more accurate data as to the absolute value of the magnetic elements and as to the extent of secular change in this part of the world than we at present possess.

VI. "On the Circulation of Air observed in Kundt's Tubes, and on some Allied Acoustical Problems." By LORD RAYLEIGH, D.C.L., F.R.S. Received October 23, 1883.

(Abstract.)

Experimenters in acoustics have discovered more than one set of phenomena apparently depending for their explanation upon the existence of regular currents of air, resulting from vibratory motion, of which theory has as yet rendered no account. This is not, perhaps, a matter for surprise, when we consider that such currents, involving as they do *circulation* of the fluid, could not arise in the absence of friction, however great the extent of vibration. And even when we are prepared to include in our investigations the influence of friction, by which the motion of fluid in the neighbourhood of solid bodies may be greatly modified, we have no chance of reaching an explanation, if, as is usual, we limit ourselves to the supposition of infinitely small motion and neglect the squares and higher powers of the mathematical symbols by which it is expressed.

In the present paper three problems of this kind are considered, two of which are illustrative of phenomena observed by Faraday.* In these problems the fluid may be treated as incompressible. The more important of them relates to the currents generated over a vibrating plate, arranged as in Chladni's experiments. It was discovered by Savart that very fine powder does not collect itself at the nodal lines as does sand in the production of Chladni's figures, but gathers itself into a cloud, which, after hovering for a time, settles itself over the places of maximum vibration. This was traced by Faraday to the action of currents of air, rising from the plate at the places of maximum vibration, and falling back to it at the nodes. In

* "On a Peculiar Class of Acoustical Figures; and on certain Forms assumed by Groups of Particles upon Vibrating Elastic Surfaces." "Phil. Trans.," 1831, p. 299.